# U.S. Climate Change Science Program: Carbon Cycle Science Program

An Interagency Partnership

http://www.carboncyclescience.gov



#### **OVERARCHING QUESTIONS**

Societal Question: What are our options for managing carbon sources and sinks to achieve an appropriate balance of risk, cost and benefits to society?

Scientific Question: How large and variable are the dynamic reservoirs and fluxes of carbon within the Earth system, and how might carbon cycling change and be managed in future years, decades, and centuries?



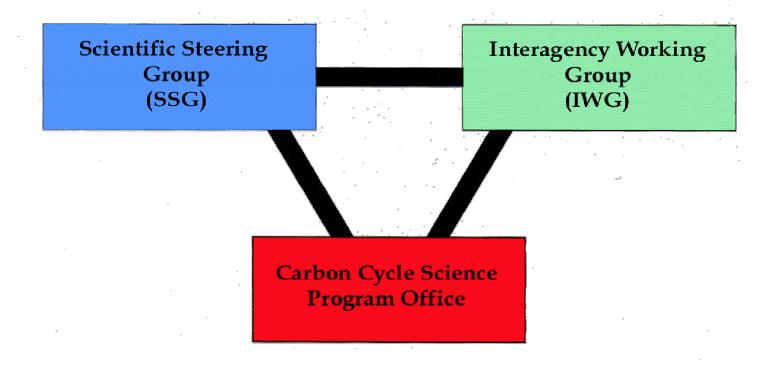
#### Why Carbon Cycle Science?

#### Information on carbon cycling is needed:

- to reduce uncertainties concerning the potential for climate change
  - projections of future atmospheric CO<sub>2</sub> and CH<sub>4</sub> concentrations
  - improved process controls for climate models
- to evaluate carbon management options being considered by society
  - effects of changes in emissions of CO<sub>2</sub> and CH<sub>4</sub>
  - effects of deliberate carbon sequestration through enhancement of biospheric storage processes or engineering approaches
- •for effective natural resource management in a changing world



#### **APPROACH AND IMPLEMENTATION**



A tri-partite implementation structure, drawn from the Carbon Cycle Science Plan, consists of a **scientific steering group** responsible for scientific guidance (Chris Field, chair), an **interagency working group** made up of representative program managers from the participating federal agencies (Diane Wickland and Roger Dahlman, co-chairs), and a carbon cycle program office (Gloria Rapalee, program officer) to serve as a liaison among the scientific community, the participating federal agencies, and the public.



#### **Critical Agency Dependencies**



- Forest & soil inventories
- Agricultural & forest managemt.
- Carbon sequestration



#### NOAA

- Meteorological observations
- Ocean surface temperature and land cover observations
- Atm. CO<sub>2</sub> flask/tall tower network
- Weather models (NCEP)
- Air-Sea CO<sub>2</sub> exchange studies
- Integrated carbon modeling
- Ship-based ocean CO<sub>2</sub> surveys



#### DOF

- Fossil fuel emissions
- AmeriFlux
- FACE and other CO<sub>2</sub> expts.
- Carbon databases (CDIAC)
- Carbon modeling
- Carbon sequestration



#### **USGS** USGS

- Landsat data & data products
- Topography & land cover maps
- Stream gauge network



#### **NASA**

- Remote sensing: satellite time series (Landsat, SeaWiFS and EOS); expt. airborne sensors
- Remote sensing research
- Field campaigns--SAFARI, LBA
- Ocean, land, atmosphere and coupled carbon-climate modeling;
- Data sets & DISS



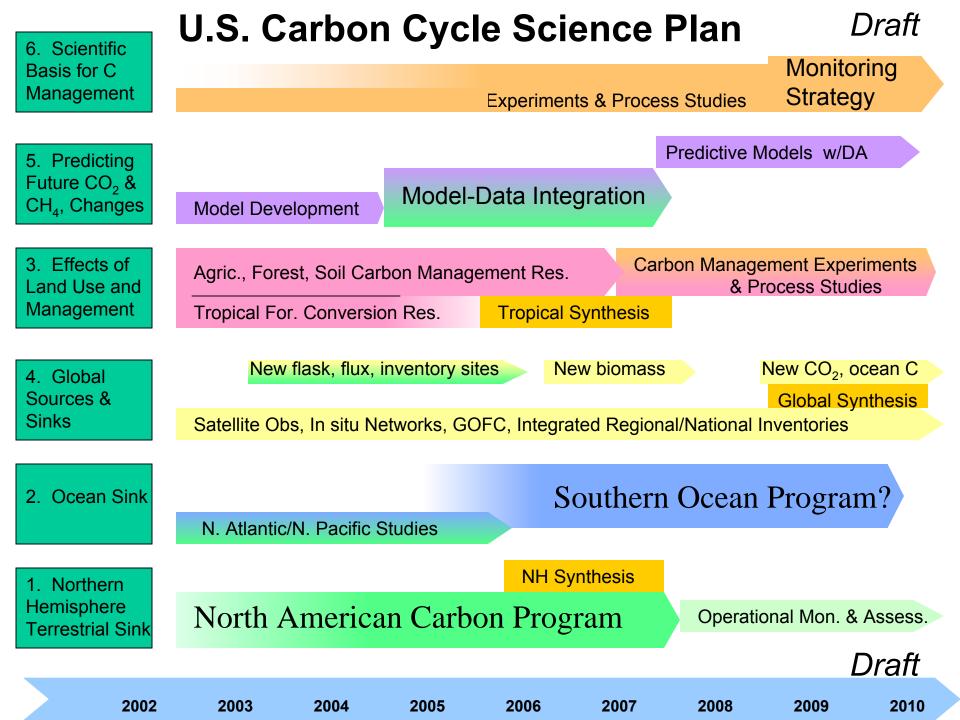
#### **NSF**

- Fundamental Earth science research
- Ocean field campaigns
- Process studies
- NCAR, NCEAS, LTER
- + NIST & ONR



#### **Carbon Cycle Science Questions**

- 1. What are the magnitudes and distributions of North American carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?
- 2. What are the magnitudes and distributions of ocean carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?
- 3. What are the effects on carbon sources and sinks of past, present, and future land use change and resource management practices at local, regional, and global scales?
- 4. How do global terrestrial, oceanic, and atmospheric carbon sources and sinks change on seasonal to centennial time scales, and how can this knowledge be integrated to quantify and explain annual global carbon budgets?
- 5. What will be the future atmospheric concentrations of carbon dioxide, methane, and other carbon-containing greenhouse gases, and how will terrestrial and marine carbon sources and sinks change in the future?
- 6. How will the Earth system, and its different components, respond to various options for managing carbon in the environment, and what scientific information is needed for evaluating these options?



1. What are the magnitudes and distributions of North American carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?

#### Research Needs: A North American Carbon Program to

- measure carbon stocks and fluxes across North America and adjacent ocean basins (enhanced networks, inventories, & surveys)
- characterize key ecosystem and ocean margin processes controlling carbon
- improve models of the carbon cycle

#### **Key Products and Payoffs:**

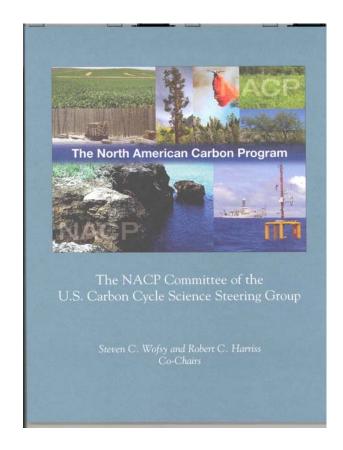
- *State of the Carbon Cycle Report: North America* (prototype 2 yrs.; full > 4 yrs.)
- carbon fluxes and stocks for managed & unmanaged ecosystems, with regional specificity and uncertainties quantified (> 4 yrs.)
- carbon cycle models with improved processes (2 yrs.) and the first use of data assimilation (2-4 yrs.)



# North American Carbon Program (NACP)

# The NACP is a coordinated research effort to:

- develop quantitative scientific knowledge of the emissions and uptake of CO<sub>2</sub>, and CH<sub>4</sub>, the changes in carbon stocks, and the factors regulating them for North America and adjacent ocean basins
- develop the scientific basis for full carbon accounting
- support long-term quantitative measurements of carbon sources and sinks and develop forecasts for future trends



A major step toward implementing the NACP was achieved with the publication of *The North American Carbon Program (NACP)* in 2002.



NACP

## U.S. Climate Change Management Structure

Committee on Climate Change Science and Technology Integration Interagency Working Group on Climate Change Science and Technology Climate Change Climate Change Science Program **Technology Program** Climate Change U.S. Global Change Research Initiative Research Program (USGCRP) (CCRI) **Carbon Cycle Science** 3 Key Science Areas



### Carbon Cycle Science Near-Term Priorities

# Our Changing Planet for combined 2004/2005 issue states:

Emphasis in the next two years will be on implementing the North American Carbon Program (NACP) and the Ocean Carbon and Climate Change (OCCC) plans developed through the auspices of the Carbon Cycle Science Steering Group. Program coordination and data management infrastructure will be established and new opportunities will be made available to conduct research in these areas. A strategy for conducting intensive research within the NACP will be communicated in 2004, and the first of these intensive field research programs and/or campaigns will be underway in *2005.* 



#### Potential Five Year Deliverables for NACP

- Consistent quantification (from independent methods) of carbon sources and sinks over North America, from regional to continental scales
- Quantification of the causes of terrestrial carbon sources and sinks, including land management, at multiple time scales
- Consistent quantification of the North American contribution to the Northern Hemisphere terrestrial carbon sink
- Specific design recommendations and prototypes for sampling networks, process research, data assimilation and prognostic modeling capabilities to improve future projections of the North American carbon balance
- First *State of the Carbon Cycle Report* (SOCCR) for North America (Synthesis and Assessment Report 2.2)



#### **NACP Program Management Plan**

- Program Office to be established (location will be selected soon)
  - Hire full-time Director
  - Staff with full/part-time detailees, etc.
- Management, coordination, and oversight by CCIWG
- Scientific leadership and direction from NACP Science Team Leaders, with scientific evaluation by CCSSG (or a sub-committee thereof?)



#### **Top-Level NACP Organizational Structure**

- Management oversight
- Funding
- Science & policy directions

**CCIWG** 

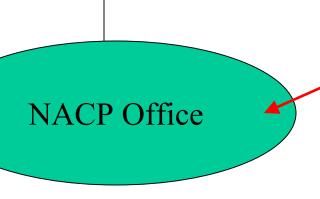
 Guidance on scientific content and directions for all Carbon Cycle Science

• Feedback on implementation

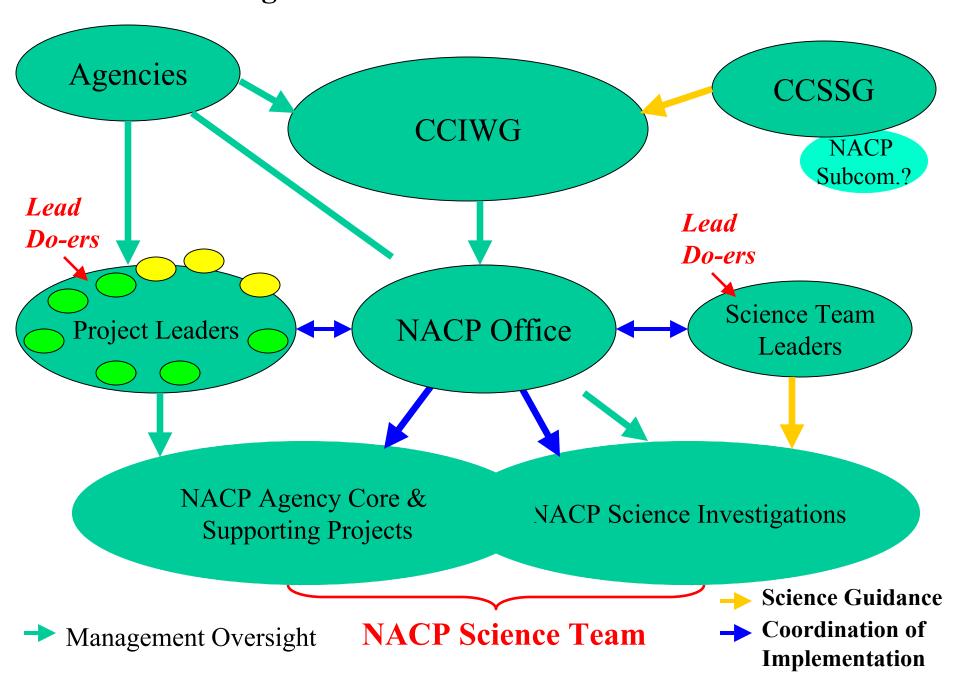
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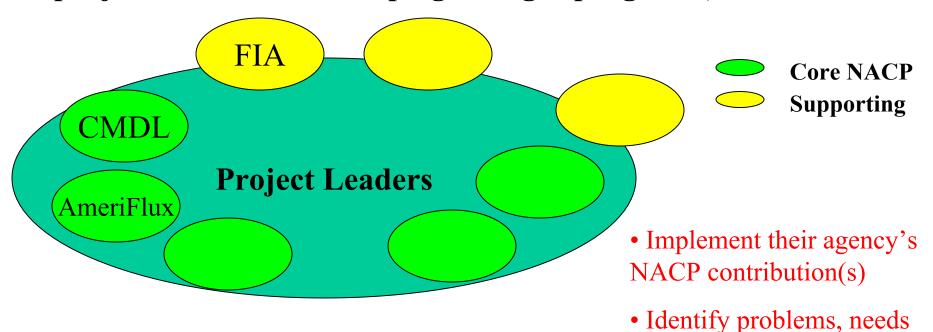
- Coordinate program implementation
- Identify problems, needs, opportunities and recommend solutions
- Provide cross-cutting infrastructure, if needed (e.g., data system, campaign HQ)?



#### NACP Office Organizational Structure: Another Level of Detail



A Plan for Engaging Managers/Scientists with Assigned Responsibilities for Major Contributions (e.g., networks, project offices, field campaigns, flight programs)



This group would be charged/tasked by the CCIWG Agencies and asked to work with the NACP Office; chairperson could rotate annually...

coordinate agency resources to meet NACP goals and facilitate synthesis &

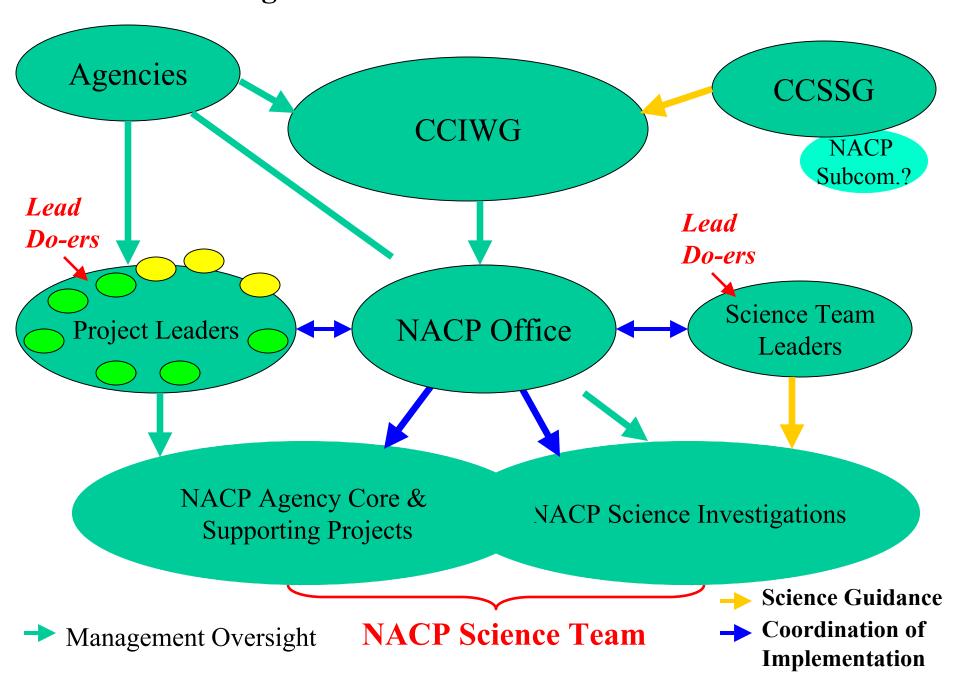
• Communicate and

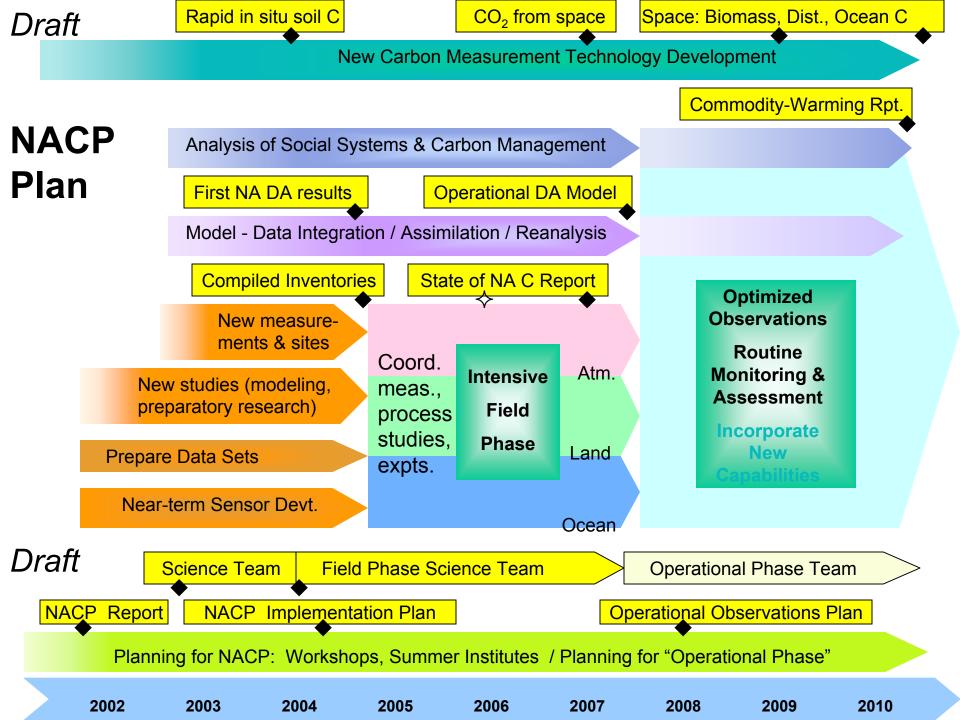
(gaps, opportunities for

synergy)

integration

#### NACP Office Organizational Structure: Another Level of Detail







#### **Partnerships for NACP**

- With U.S. Neighbors to the North and South
  - Canadian scientists involved in science planning
  - Discussions with Canadian Government ongoing (ad hoc working group)
  - U.S.-Canada bilateral includes detailed statement of intent to work together on NACP (drafted in advance by ad hoc U.S.-Canada NACP working group)
  - U.S.-Mexico bilateral identified NACP as an activity of interest; small program-oriented workshop scheduled for this fall

#### With Europe

- U.S.-EU bilateral discussions to cross compare results, work on Northern Hemisphere carbon budget, and develop measurement protocols and standards



#### **NACP: Near-Term Events**

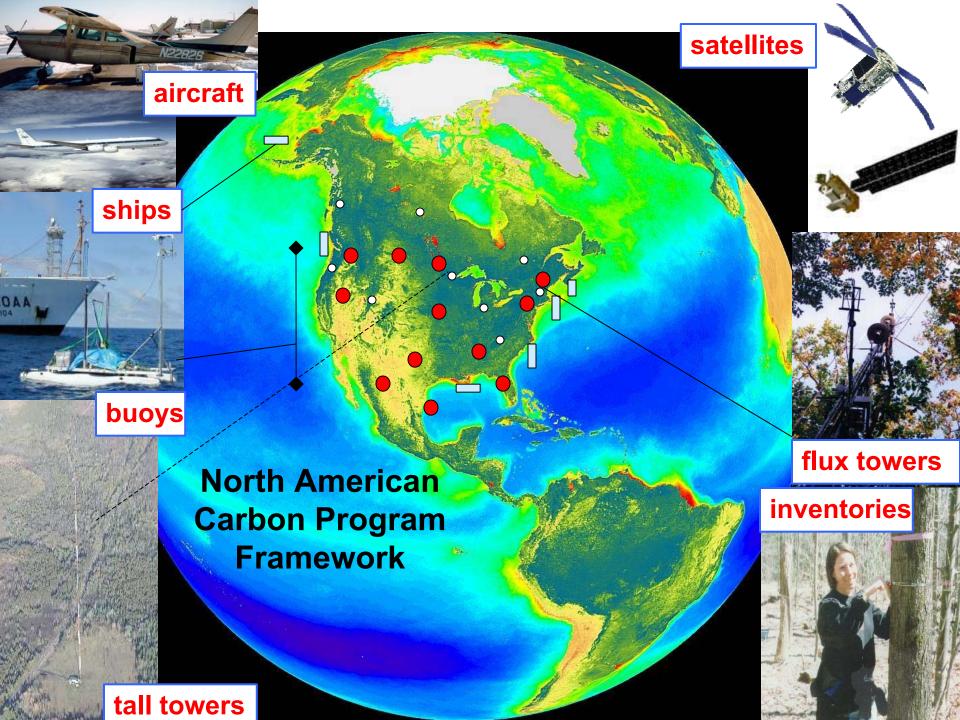
#### Workshops planned

- Remote Sensing for NACP (MT)
- In situ science for Mid-Continent Intensive (IA)
- AmeriFlux
- LULC Carbon Program Coordination Workshop
- Data Management for NACP
- Ocean Carbon (will include NACP coastal & ocean work)
- Workshops to be developed
  - to further develop/prioritize other *Intensives* for NACP
  - NACP science development for integrated North American analysis with Canada (& Mexico?)



### **CCSP Synthesis and Assessment Reports**

- SAR 2.2 (first SOCCR), North American carbon budget and implications for the global carbon cycle, is one of the first three expected to move forward delivery is expected "within 2 years" (i.e., autumn, 2005)
- Responsibility for the deliverable has been assigned to a lead agency(ies) (they should coordinate with supporting agencies, relevant IWGs, other CENR subcommittees . . .)
  - Lead Agencies: DOE (R. Dahlman), NASA (D. Wickland & E. Sheffner), NOAA (D. Hofmann)
  - Supporting Agencies: USDA (Bryce Stokes), USGS (tbd)
- Proposal from a team of U.S. scientists to prepare the first SOCCR (SAR 2.2) has been selected





#### **Role of Remote Sensing in NACP**

- Regional and Continental-Scale Satellite Data Products to:
  - Drive carbon models & Use in data assimilation
  - Quantify land cover and characterize and quantify disturbance
  - Stratify sampling & Design experiments/intensive studies
  - Extend site data across landscapes, regions & continent
  - Make needed measurements directly (e.g., OCO towards end of decade)
- Airborne Data Acquisitions (in situ chemical observations and surface imagery) to:
  - make unique measurements (e.g. chemistry, waveform lidar)
  - provide an intermediate type of measurement to aid in scaling up from site-based to space-based observations
  - make measurements in combinations or at times not available from space

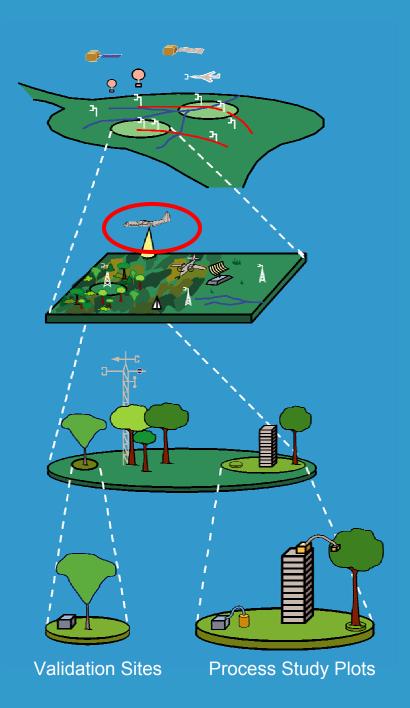
# Scaling Strategy

100 - 10,000 km Region to Continent

1 - 100 km Study Areas & Intensives

~ 1 km Flux Tower Sites

1 - 10 m Process Study Plots Validation Sites





### Role of Remote Sensing in NACP

- In addition to aiding in answering science questions, airborne remote sensing can:
  - test new measurement methodologies or technologies before deployment in space
  - in combination with rich field data from NACP, aid in validating satellite data products
- ... these uses are important and highly relevant, especially to NASA, but it would be helpful if such objectives could be explicit and considered distinct from those that aid directly in answering NACP questions.



## **Ongoing NACP Remote Sensing Tasks**

- Over past 2 years many new research investigations have been funded by DOE, NASA, NOAA, NSF, USDA, and USGS to conduct NACP or NACP-relevant research (including CCRI funding)
- Just last month NASA, DOE & USDA announced a new group of investigations selected in response to solicitation focused on NACP
- Other opportunities to propose will follow in subsequent years
- There is an urgent need to improve the coordination of these research activities and foster synergistic interactions; "formal" Science Team meetings, a proposed Science Steering Group, and the soon-to-be-established NACP office should help . . .
- A partial task list was compiled to inform participants at this meeting please be aware it is neither complete for any one agency nor comprehensive some titles are not even correct. .

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# **Ongoing NACP Remote Sensing Tasks**

Agency	PI Name	PI Institution	Investigation Title
NASA	Asner, Gregory	Carnegie Institution of Washington	Regional Carbon Storage Responses to Woody Encroachment in Western Pinyon-Juniper Systems
NASA	Balch, William M.	Bigelow Laboratory for Ocean Sciences	Using remote sensing to understand the consquences of climate, sea level changes, and increased human activities in the coastal Gulf of Maine
NOAA	Barnet, Chris D.	NOAA/NESDIS	Satellite Carbon Dioxide Retrievals
NASA	Behrenfeld, Michael	NASA Goddard Space Flight Center	Ocean Productivity from Satellite-Derived Phytoplankton Physiology and Carbon Biomass
NASA	Birdsey, Richard	USDA Forest Service	Linking Landscape-scale Carbon Monitoring with Forest Management
NASA	Bolstad, Paul	University of Minnesota	Land Use, Carbon, and Water in the Uplands of Southeastern North America
NASA	Bolstad, Paul	University of Minnesota	Testing the flux tower upscaling hypothesis at a regional scale in a complex landscape
NASA	Chopping, Mark	Montclair State University	Quantifying Changes in Carbon Pools with Shrub Invasion of Desert Grasslands Using Multi-Angle Data from EOS Terra and Aqua
USDA	Daughtry, Craig and others	Hydrology and Remote Sensing Laboratory, Beltsville	Spectral and Spatial Measurements and Modeling to Improve Nutrient Management and Environmental Quality

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#### **Questions for this Workshop**

We have a lot or remote sensing research relevant to NACP goals and objectives underway now, but

- Is it enough? Are we collecting all the data we need? Do we have all of the tools we need? What is missing?
- Will the right products for analyzing North America's carbon budget be available when we need them?
- What can be done to coordinate the individual tasks?
- How can we foster synergistic interactions among the researchers so that data products are compatible and integrative analyses facilitated?
- What types of studies and/or expertise are lacking?



### **Workshop Success?**

- Stimulate dialogue, interactions and cooperation amongst the participants
- Make recommendations to the CCIWG / agencies concerning needed activities, actions, issues to address, etc.
- Prepare / plan to support the Mid-Continent intensive